Equine Posture Analysis: Development of a simple tool to record equine thoracolumbar posture

Gillian Tabor[a*], Ami Elliott[a], Natacha Mann[a], Jane Williams[a]

[a]Equestrian Performance Research and Knowledge Exchange Arena, Hartpury University, Gloucester, UK, GL19 3BE *Corresponding author gillian.tabor@hartpury.ac.uk

Abstract

Background: Musculoskeletal assessment of horses includes assessment of conformation, symmetry and postural alignment of the equine spine however objective methods to analyse the spine have high costs and are logistically complex.

Objective: This study aimed to assess the intra- and inter-rater reliability of simple methods designed to objectively measure thoracolumbar (TL) posture from photographs.

Methods: A sample of horses (n=190) were photographed with a digital camera in two positions of stance and also a static image was captured from video at the toe off phase of the right hind in walk. Measurements of TL angle, depth and area of lordosis were tested for intra and inter reliability.

Results: Repeated measures of TL angle showed no significant differences between measurements taken by one observer but TL depth and surface area measures were not found to be consistently reliable. Inter-rater reliability was poor for all measurements across three observers.

Conclusion: TL angle method of recording thoracolumbar posture in horses has the potential to be used to gain an objective measure of posture when standardised positioning is applied by a single experimenter or clinician.

Highlights

- Musculoskeletal assessment of horses includes assessment of posture
- Objective, simple measures of equine thoracolumbar posture have not been tested for reliability
- Calculation of equine thoracolumbar angle is reliable with one observer but not with multiple observers
- Calculation of equine thorocolumbar depth or area is not reliable for either one or more observers.
- The thoracolumbar angle method could be used to objectively measure outcome of treatment interventions if repeated by a single observer

Introduction

Musculoskeletal assessment of horses includes assessment of conformation, symmetry and postural alignment of the equine spine [1,2,3]. In the quadruped mammal, the thoracolumbar (TL) spine is aligned horizontally, with a position of relative extension described as lordotic and in the horse,if this lordosis is increased, may contribute to osseous and/or soft tissue injuries [4]. Vertebral problems have been associated with changes in neck posture [5] as well as roundness of neck and back shape [6], and higher muscle activity (via surface electromyography) has been measured at the level of affected vertebrae [7]. These changes may also TL lordosis and therefore the relative TL posture. Anecdotally TL lordotic posture has been related to spinal pain and pathology in the TL regions. However objective methods to analyse the spine for pathology underlying a change in posture, such as radiography, ultrasonography or scintigraphy have high costs, are logistically complex and require extensive training for the clinician as well as presenting risks such as exposure to radiation. An objective, simple and economic measure of equine spinal posture that could be incorporated into daily practice 'in the field' would be beneficial, allowing assessment of posture change with following treatment and rehabilitative training.

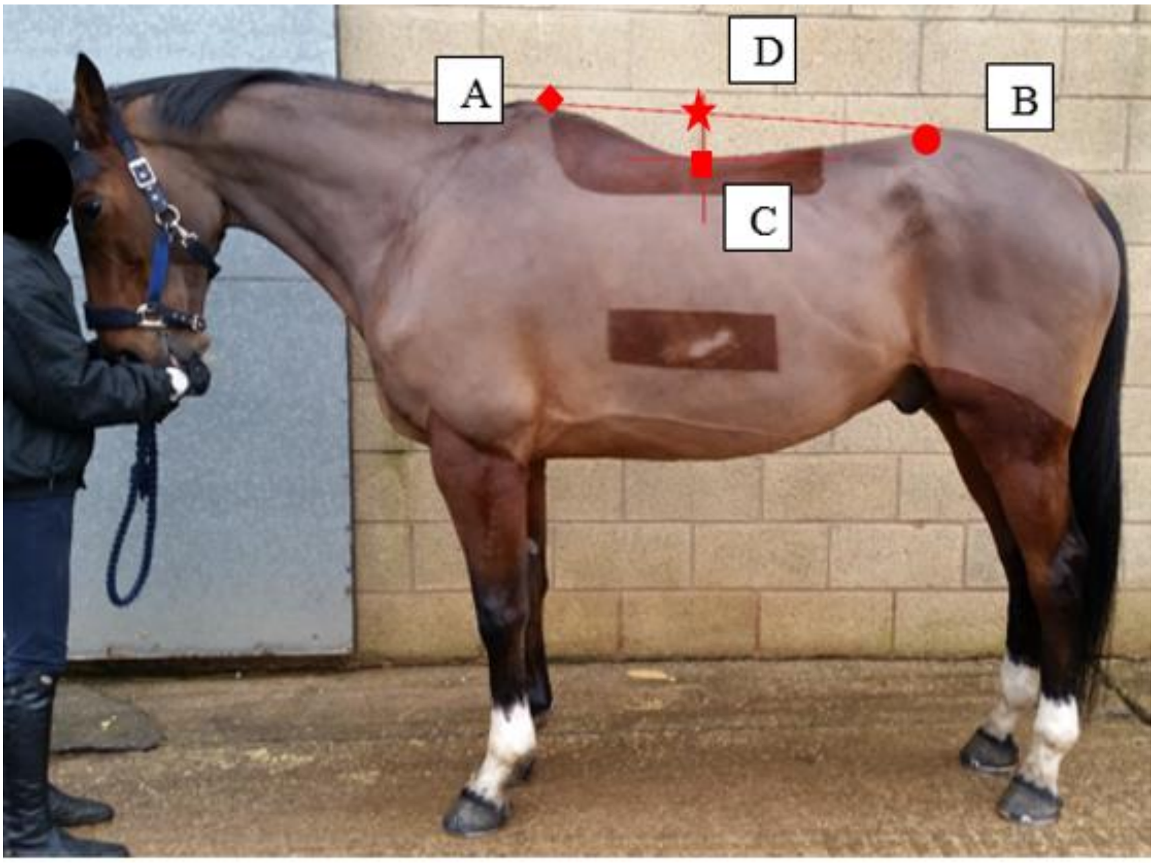
Posture of the spine is routinely assessed in human patients to examine its relationship to low back pain [8,9] and a pilot study, with a small sample size, of equine posture also assessed sagittal view photographs in neutral 'square' stance [1], finding good reliability of measures of thoracolumbar posture with a single observer. However, positioning a horse in a single standardised position is challenging, time consuming and therefore for ease of practical application it would be more convenient to be able to measure TL posture in horses during relaxed stance or during gait, similar to neck posture in ridden [5] and in standing horses [7]. The reliability of such data have not been tested to date, therefore this study aimed to assess the intra- and inter-rater reliability of simple methods designed to objectively measure thoracolumbar posture from a single image image of a horse in neutral and relaxed standing postures, and between images of stance and a single point during the walk cycle..

Methods

The equine subjects were opportunistically selected from private stable yards and two equestrian colleges. Inclusion criteria were: horses aged four years or above, in ridden exercise without any current veterinary management for injury, lameness or illness. All horses wore their normal head collar or bridle for controlling movement.

Two groups of horses were photographed with a Smartphone camera (8-megapixel resolution; camera height level with mid thoracic spine, aligned to the longitudinal axis and 2 metres from horse), with a visible marker of known length in the frame to allow for image calibration and accurate digital measurement for measurement of TL depth in millimetres [10] (figure 1). Group one (n=90) horses were stood on a concrete surface two positions, in random order: feet aligned or feet non-aligned both positions with head aligned vertically, chin level with shoulder. For collection of a dynamic image of posture group two (n=100) horses, after being photographed in stance with feet aligned, were also walked, across a flat hard surface, perpendicular to the camera at approximately five metres from the camera and a video recording (frame rate: 60 frames per second) was collected. Videos were viewed in Windows Movie Maker (Microsoft Corporation, Redmond, WA, USA) to obtain a static image with the horse's right hind leg in the toe off phase of gait, these were extracted for analysis [11].

Digital images were exported to ImageJ™ software (NIH, Bethesda, Maryland, USA) for analysis. The dorsal angle of thoracolumbar spine (TLangle) (Angle ACB°), the depth of the thoracolumbar lordosis (TLdepth) (Length DC: cm) and the area of the lordosis (TLsa) (Area between line AB and curve of the dorsal profile AB: cm²) (figure 1) were measured three times with the observer blinded to previous measurements and a median calculated [1]. To test inter-rater reliability 50 images, randomly selected from the photographs of stationary group 2 horses, ,the TLangle, depth and area were measured once by three different measurers.



Markers shown on an equine subject, stood with forefeet and hind feet aligned with equal left/right weight bearing and head aligned vertically, chin level with shoulder joint. Symbols added to represent locations used for thoracolumbar posture measurements: A/♦ = Highest point of withers; B/● = Highest point of lumbar or pelvis region; C/■ = Lowest point of thoracolumbar region; D/★ = point on line AB where vertical line from C bisects.

Figure 1. Marker location for measurement of sagittal alignment.

A-priori sample size calculations identified the minimum sample size required to reduce the potential for type I (alpha: 5%) and type II (beta: 20%) errors [12]. A minimum of 80 horses and more than 2 experimenters were identified to meet these criteria to give a valid representation of inter and intra reliability with an effect size of 0.5.

Statistical Analysis

Data did not meet the requirements for parametric statistical analysis, therefore non-parametric analyses were undertaken using SPSS statistical package version 23 (SPSS Inc, Chicago, IL). Repeated measures of each image were tested with related samples Friedman's two way analysis of variance.

Intraclass correlation estimates (ICC) and their 95% confident intervals (CI) were calculated based on a mean-rating (k = 3), absolute-agreement, 2-way mixed-effects model [13]. To assess for differences between thoracolumbar posture in static and dynamic images, and between neutral and relaxed postures, a series of Wilcoxon signed-rank tests were used. For all tests alpha was set at 0.05.

Results

A total of 380 images were obtained and analysed (table 1).

Table 1: Equine thoracolumbar posture measurements

Median and interquartile range (IQR) measurement for each group of images for thoracolumbar angle (TLangle), depth (TLdepth) and surface area (TLsa).

Measurement Method	Group 1		Group 1 total sample size	Group 2		Group 2 total sample size
	Static Neutral	Dynamic		Static Neutral	Static Relaxed	
TLangle (^{o})	Median: 150.5 IQR = 4.4 n=90	Median: 155.8 IQR = 4.8 n=90	n = 180	Median: 149.1 IQR = 4.6 n=100	Median: 148.6 IQR = 5.4 n=100	n =200
TLdepth (cm)	Median: 9.1 IQR = 1.9 n=33	Median: 11.1 IQR = 3.2 n=33	n=66	Median: 9.8 IQR = 1.7 n=72	Median: 9.6 IQR = 1.7 n=72	n =144
TLsa (cm^2)	Median: 331.5 IQR = 66.2 n=90	Median: 600.8 IQR = 254.8 n=33	n = 66	Median: 462.4 IQR = 113.2 n=72	Median: 457.1 IQR = 105.9 n=72	n =144

Intra-rater reliability

Intra-rater reliability was excellent between each of the three measures for TLangle with no significant differences found within experimenters (Group 1: $\chi 2(2)=1.872$, p=0.392; ICC: 0.989; CIs: 0.986-0.991; Group 2: $\chi 2(2)=2.790$ p=0.248; ICC: 0.987; CIs: 0.983-0.990) [13]. In contrast, reliability differed between the two groups assessed for TLdepth and TLsa. Measurement of TLdepth in Group 1 images was not consistent ($\chi 2(2)=7.826$ p=0.020; ICC: 0.994; CIs: 0.991-0.996) however intra-rater reliability was excellent for Group 2 ($\chi 2(2)=3.737$ p=0.154; ICC: 0.989; CIs: 0.981-0.989). For TLsa measurement, Group 1 demonstrated excellent intra-rater reliability ($\chi 2(2)=2.279$ p=0.320; ICC: 0.997; CIs: 0.996-

0.998) however this was not repeated for Group 2 data, were significant differences between measurements were found ($\chi2(2)=11.014$ $p=0.004$; ICC: 0.995; CIs: 0.994-0.996).

As significant differences between measurements occurred for TLdepth and TLsa, only TLangle data were analysed for differences by position. Significant differences were found for TLangle between the group 1 static and dynamic postures as well as group 2 static neutral and static relaxed images (Group 1: $z=8.201$, $p=0.000$, $r=.86$; Group 2: $z=-3.661$, $p=0.000$, $r=-.37$).

Inter-rater repeatability

TLangle, depth and surface area measurements were all significantly different (TLangle $\chi^2(2)=72.840$ $p=0.000$; ICC: 0.765, CIs: 0.182-0.910; TLdepth $\chi^2(2)=34.120$ $p=0.000$; ICC: 0.915; CIs: 0.818-0.956; TLsa $\chi^2(2)=14.68$ $p=0.001$, ICC: 0.933; CIs: 0.887-0.961) demonstrating poor inter-rater reliability between the measurements assessed.

Discussion

Three methods were used to obtain measurements of posture from sagittal images of horses standing square, in a relaxed position and images from walking gait. TLangle method showed no significant differences between measurements taken by one observer supporting the results obtained previously [1] suggesting that TLangle method could be used to measure of thoracolumbar posture. Differences were noted between the stance positions assessed for TLangle, therefore it would be essential that the horse is positioned with the same feet and head alignment to ensure reliability when assessing posture. However the current study was limited to only measuring each horse at one moment in time, with no repeated photographs taken to see if posture altered over time. Tabor and Randle [1] took three images of each horse at 30-minute intervals and found no differences in repeated measures but concluded that this may be due to the absence of extraneous factors that could influence posture occurring in that time frame.

The depth and surface area method were not found to be consistently reliable; this may be due to the increased accuracy required to measure the distances, AB and CD (figure 1) and trace the dorsal profile with the curser in Image J™. Therefore, these methods of recording posture of the equine thoracolumbar spine should not be considered reliable. There were also significant differences when comparing TLangle from photographs of a horse stood square and the same horse in walk. This indicates that the spinal posture was different in these two conditions, supporting the need for consistency in the position used and subsequent repeatability of positioning, for taking measures at different time periods.

Inter-rater reliability was poor for all measurements across the three observers, suggesting that none of these methods are suitable for use when more than one assessor is assessing spinal posture.

Conclusions

Analysis of equine posture can be made by a single observer measuring the angle of the thoracolumbar spine from a single image of a horse stood in a neutral position. However measurement of TL depth or surface area was not repeatable by a single observer and measurement of TL posture during gait did not relate to posture in stance. None of the methods tested were repeatable with more than one observer. The TLangle method of recording thoracolumbar posture in horses, used by the same observer, has the potential to be used to gain an objective measure of posture when standardised positioning is applied by the experimenter or clinician. Therefore, this measure is useful and clinically applicable if the same person assesses posture throughout of treatment, for example. The validity of this objective measure could now be tested to assess changes in TL posture and potentially used to document the outcome of intervention effects on spinal posture.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethics: Ethical approval gained from the University Centre Hartpury Ethics Committee

Conflicts of interest: none

References

[1] Tabor, G.F. and Randle, H. (2013) Validation of a simple method to quantify equine thoracolumbar posture. *Proceedings of the ninth International Society of Equitation Science Conference.* USA

[2] Van Weeren, P.R., McGowan, C., Haussler, K.K., 2010. Science overview: Development of a structural and functional understanding of the equine back. *Equine Veterinary Journal*, *42*(s38), pp.393-400.

[3] McGowan, C.M., Stubbs, N.C., Jull, G.A., 2007. Equine physiotherapy: a comparative view of the science underlying the profession. *Equine Veterinary Journal*, *39*(1), pp.90-94.

[4] Cocq, P.D., Weeren, P.V., Back, W., 2004. Effects of girth, saddle and weight on movements of the horse. *Equine Veterinary Journal*, *36*(8), pp.758-763.

[5] Lesimple, C., Fureix, C., Menguy, H. and Hausberger, M., 2010. Human direct actions may alter animal welfare, a study on horses (Equus caballus). *PloS one*, *5*(4), p.e10257.

[6] Fureix, C., Hausberger, M., Seneque, E., Morisset, S., Baylac, M., Cornette, R., Biquand, V. and Deleporte, P., 2011. Geometric morphometrics as a tool for improving the comparative study of behavioural postures. *Naturwissenschaften*, *98*(7), p.583.

[7] Lesimple, C., Fureix, C., De Margerie, E., Sénèque, E., Menguy, H. and Hausberger, M., 2012. Towards a postural indicator of back pain in horses (Equus caballus). *PloS one*, *7*(9), p.e44604.

[8] Mitchell, T., O'Sullivan, P.B., Burnett, A.F., Straker, L., Smith, A., 2008. Regional differences in lumbar spinal posture and the influence of low back pain. *BMC Musculoskeletal Disorders*, *9*(1), p.152.

[9] Smith, A., O'sullivan, P., Straker, L., 2008. Classification of sagittal thoraco-lumbo-pelvic alignment of the adolescent spine in standing and its relationship to low back pain. *Spine*, *33*(19), pp.2101-2107.

[10] Dyson, S.J., Tranquille, C.A., Collins, S.N., Parkin, T.D.H., Murray, R.C. 2011. An investigation of the relationships between angles and shapes of the hoof capsule and the distal phalanx. *Equine Veterinary Journal.* 43, 295–301.

[11] Faber, M., Schamhardt, H., Weeren, R.V., Johnston, C., Roepstorff, L. and Barneveld, A.B., 2000. Basic three-dimensional kinematics of the vertebral column of horses walking on a treadmill. *American Journal of Veterinary Research*, *61*(4), pp.399-406.

[12] Jones, S.R., Carley, S. and Harrison, M., 2003. An introduction to power and sample size estimation. *Emergency Medicine Journal*, *20*(5), pp.453-458.

[13] Koo, T.K. and Li, M.Y., 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), pp.155-163.